Salmon spawning in Katmal National Monument

Chapter 14 Fish Conservation Measures

The Columbia Fishery

The Pacific Northwest is famous for its annual runs of salmon and steelhead trout. These anadromous fish, which spawn in freshwater and grow to maturity in salt water, depend on the Columbia River system for their existence. The tributaries of this mightly stream provide their spawning grounds, and the main stem gives them access to the ocean. As one of the most productive salmon rivers in the world, the Columbia River still supports a $200 million annual salmon and steelhead trout fishing industry. The heavy pressures on this resource, however, threaten to destroy it.

For centuries, man has exploited the fish runs of the Columbia River. Indians invested the salmon with religious significance and harvested them with spears and dipnets as a prime food source. The 19th-century white settlers in the Columbia basin developed vast

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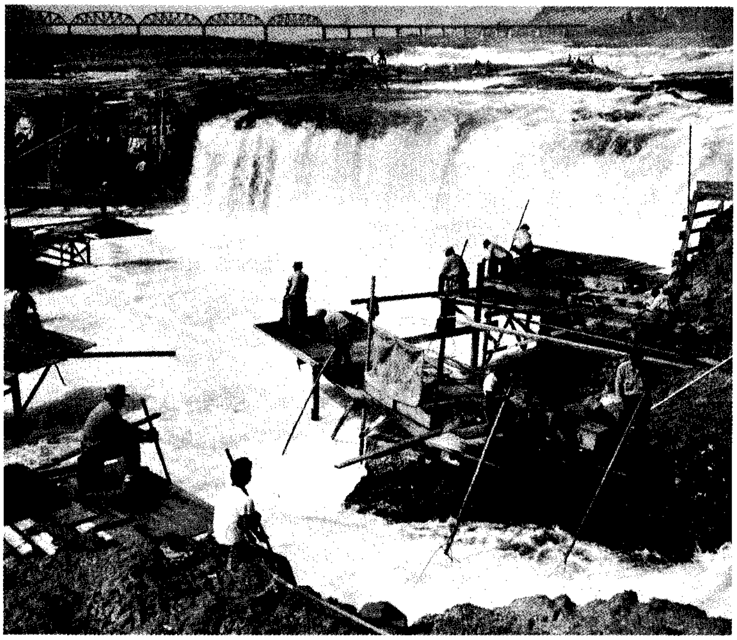
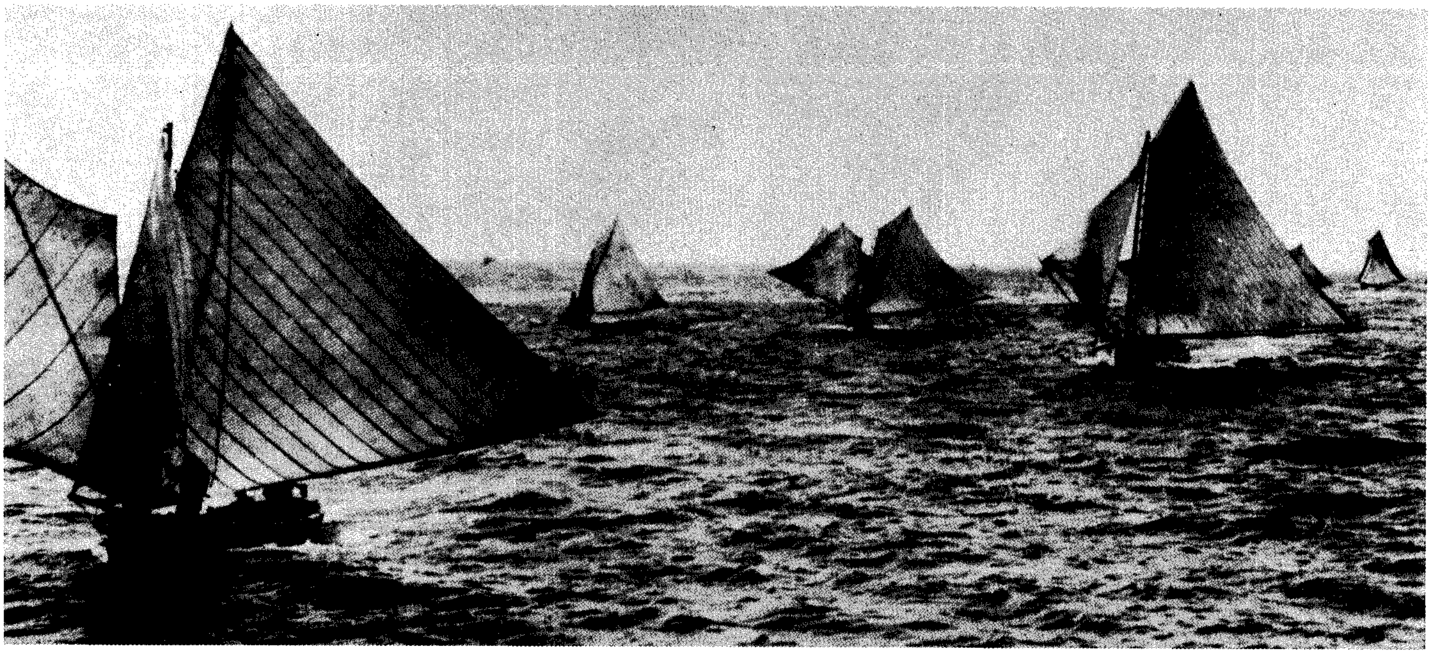


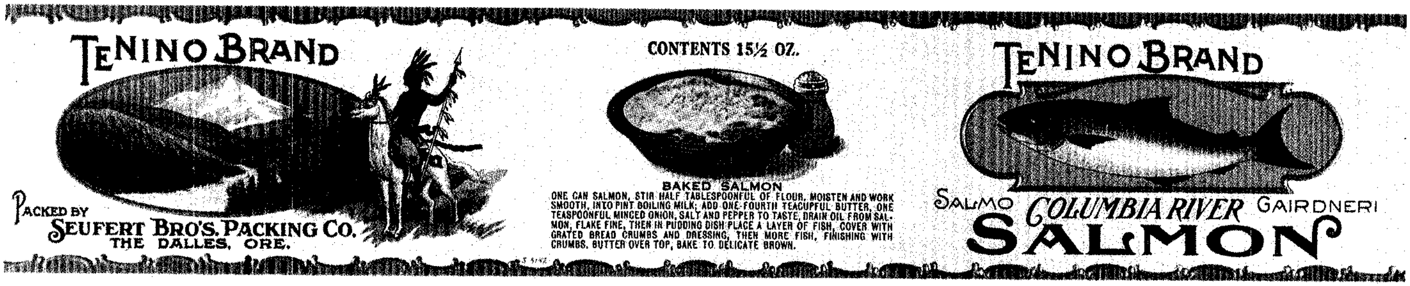
Indians fishing at Celilo Falls

Traditional dip net technique used at falls of Columbia River.

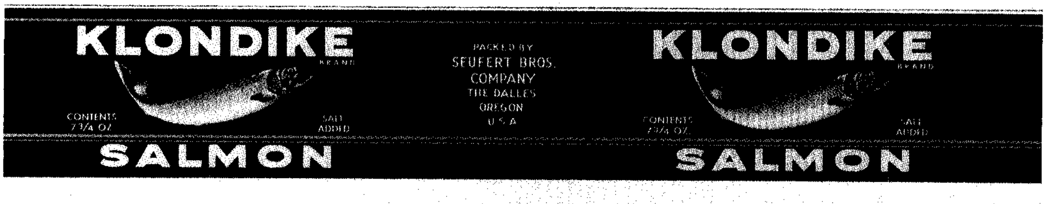


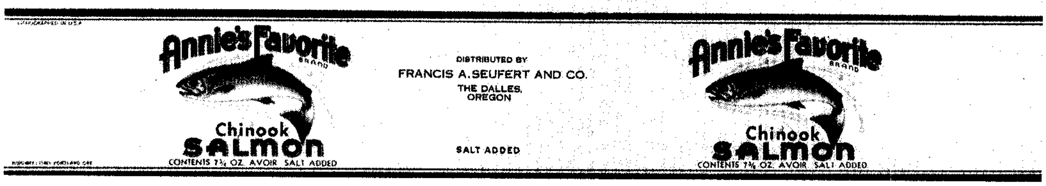
above: "Butterfly" fish boats at mouth of the Columbia River, right: Horses were used for pulling fish nets from water in Columbia fishing operations.

Commercial catches were bountiful in the early years of the Columbia fishery.



above and right: Lables from Seufert Brothers canned salmon products. The Seufert cannery, established in 1886, was located in The Dalles, Oregon.



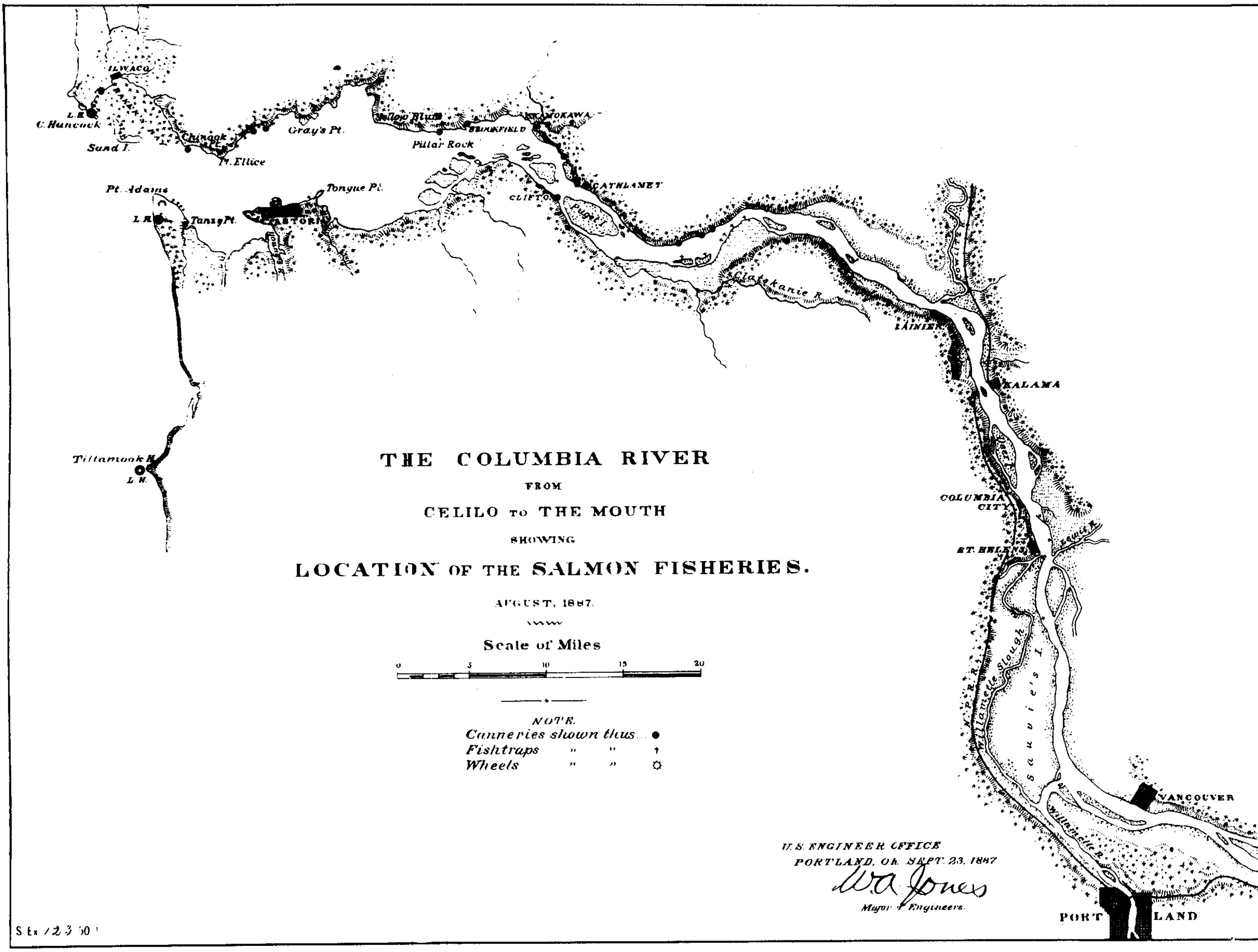


commercial and sport fisheries. The salmon canning industry, begun in 1866, grew rapidly. Starting with 4,000 cases packed in the first year of operation, the industry reached its all-time high of 634,696 cases in 1895. Such pressures on the fishery resource inevitably brought overuse and decline. The best industry years came in the mid-1880s and by 1975 the amount of salmon canned dropped below 18,000 cases, a level below the pack of 1867. In 1977, Columbia River packers canned only 1,559 cases.[1]

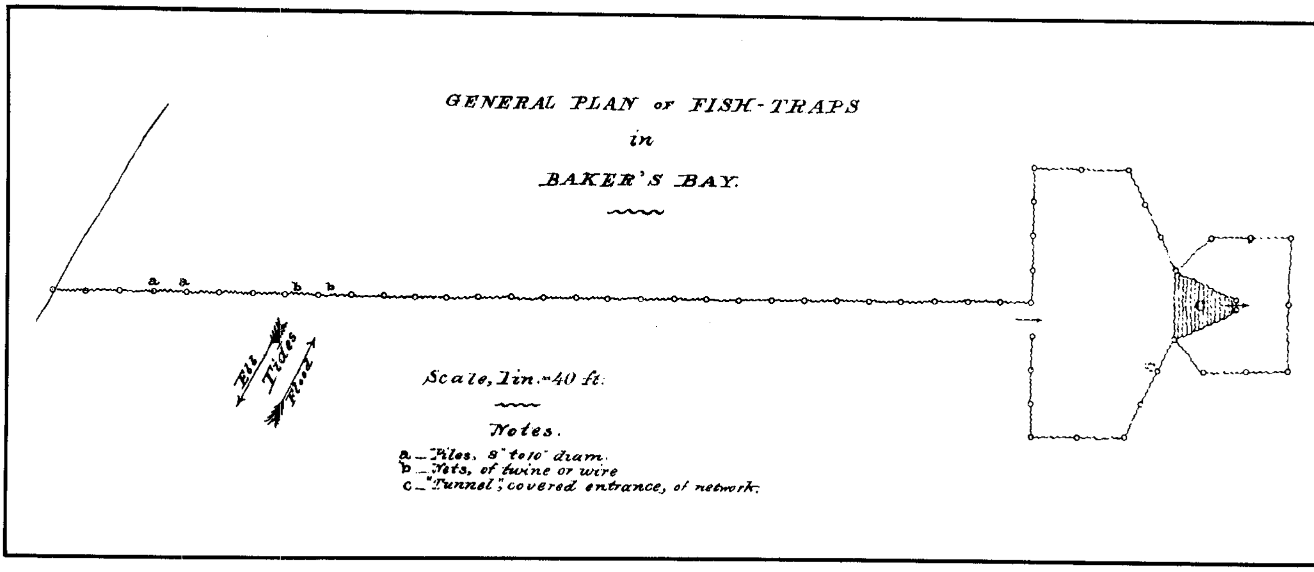
Major William Jones, in charge of one of the Corps of Engineers' offices in Portland in the late 1880s, recognized that overfishing menaced the existence of the runs. In 1887, Congress ordered the Corps to investigate the salmon fisheries of the Columbia River, with special reference to possible obstructions of navigation by various fishing devices. Jones, reporting in 1888, noted "an enormous reduction in the numbers of spawning-fish, brought about through this fishing industry." He also cited stream pollution as a factor in declining fish runs. While admitting a dearth of information for a "complete and satisfactory solution of the fishery question, . . . enough is known," he stated, "to show that hatcheries and a weekly close season should be established without delay." He recommended further study of Columbia River salmon.[2]

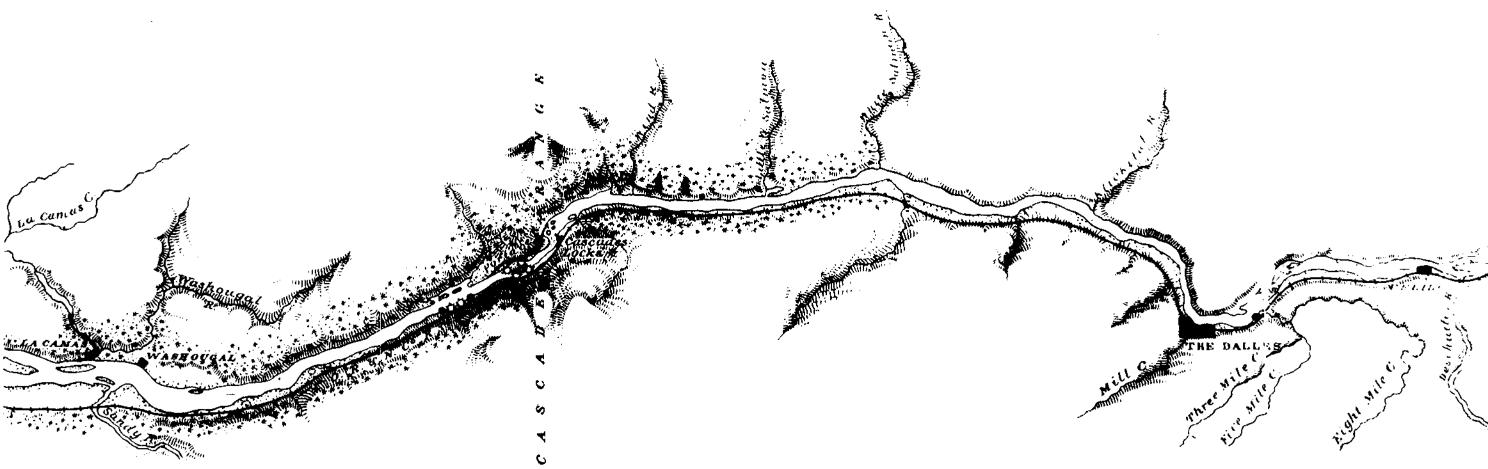
Fishermen knew the resource was limited, and gillnetters and trapmen competed fiercely. As early as 1884, the Columbia River Fishermen's Protective Union, representing the gillnetters, lobbied the Corps of Engineers to remove traps from the lower Columbia as hazards to navigation. This request generated a controversy that raged for many years. Both Powell and Jones, officers in charge of the Portland offices, recognized the request as a ploy to benefit one group at the expense of another. Their investigations did not find the traps obstructions in general, and they refused to take sides in the dispute. However, both recommended that the Corps seek authority to regulate the location of traps to prevent development of possible hazards to navigation. Under provisions of the 1890 Rivers and Harbors Act, subsequent engineer officers did force the removal of the occasional trap blocking navigation. Systematic regulation eventually resulted from a part of the Rivers and Harbors Act of 1899, known as the Refuse Act. Thereafter, fishermen needed permits from the Corps of Engineers to place traps in the Columbia. In 1900, Captain Langfitt acted on 132 such applications; and in the following year he approved 73 out of 108 applications submitted.[3]

Unfortunately, the permit system did not still the controversy between the gillnetters and trappers. Both sides continued to exert political pressure on the Corps to support their respective positions. Throughout the protracted dispute, Portland district engineers



above: Map of the Columbia River indicates placement of the numerous salmon fisheries and canneries on the river.
right: Salmon fishing on the Columbia near Wishram, far right: Salmon fishing scow, inset, upper right: diagram of typical fish trap used on Columbia.


GENERAL PLAN OF FISH-TRAPS
in
BAKER'S BAY.
Ebb
Tides
Flood
Scale, 1in.=40 ft.
Notes.
a _ Piles, 8" to 10" diam.
b _ Nets, of twine or wire
c _ "Tunnel", covered entrance, of network.


La Camas C.
Washougal R.
LA CAMAS
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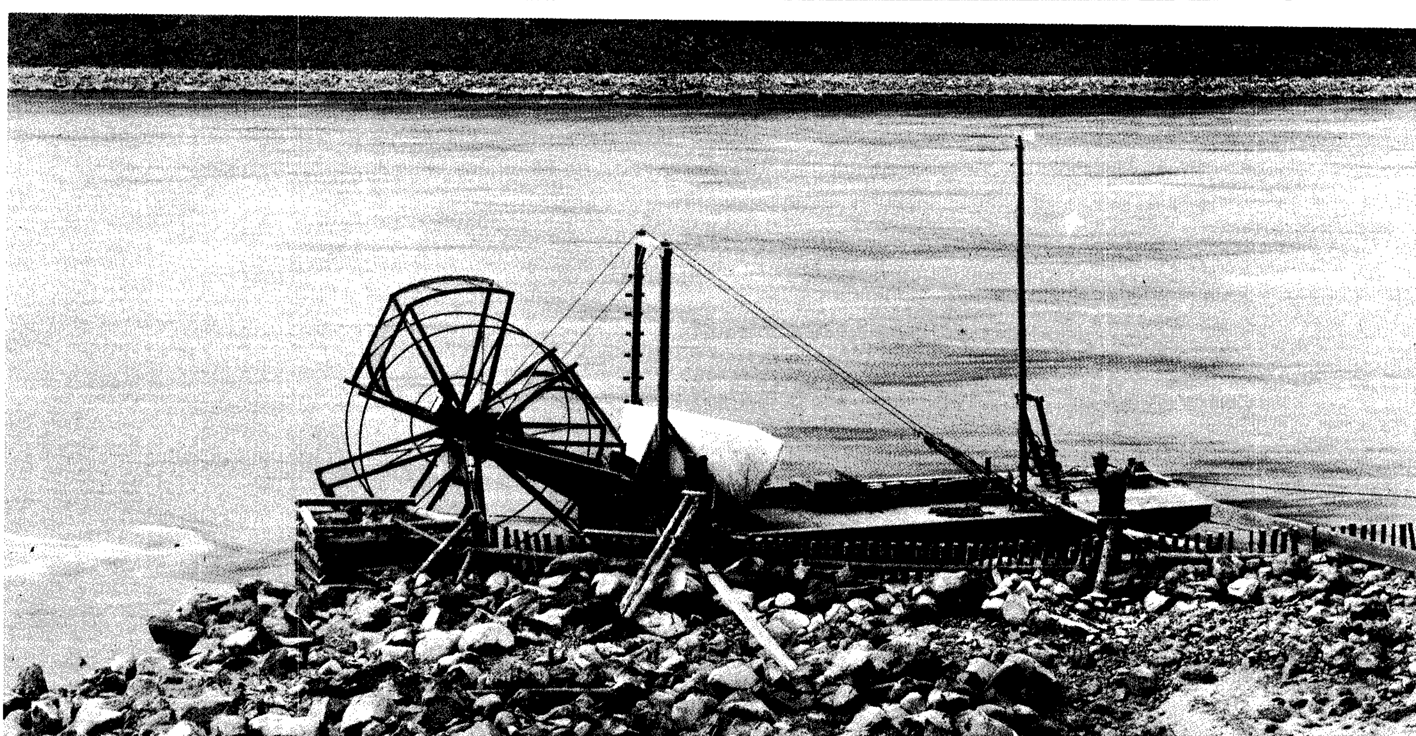
Sandy R.
CASCADE RANGE
Cascade Locks
THE DALLES
Mill C.
Three Mile C.
Five Mile C.
Eight Mile C.



continued regulating traps solely on the basis of their impact on navigation. In 1901, Captain Langfitt stated the district's long-held view in the matter: "The differences and contentions between the two classes of fishermen are not matters for adjustment by the War Department." He added that "so far as any damage or injury which one class may inflict on the other is concerned, the remedy is in the local courts under local laws."[4]

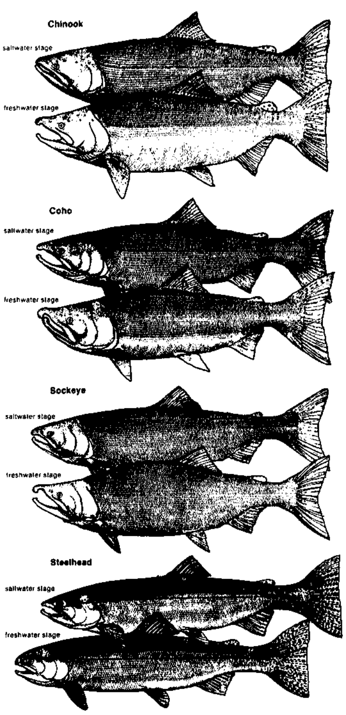
The federal government and states of Oregon and Washington responded slowly to the need for fishing regulations. Oregon established the first salmon hatchery in the Columbia Basin on the Clackamas River in 1877; Washington followed suit, building 15 by 1900. Both states began regulating fishing gear and experimenting with seasonal restrictions on taking fish, but none of the measures received vigorous enforcement. Oregon and Washington did not ban the fishwheel, the most objectionable device, until 1926 and 1934, respectively.[5]

Bonneville Fish Passage Facilities

Meanwhile, overfishing, pollution, unscreened irrigation ditches, and spoiled spawning grounds relentlessly destroyed the fish runs. The big multiple-purpose dams provided the final blow, threatening to block the salmon and steelhead from reaching either their upstream spawning grounds or the sea. In the early 1930s, the fishing industry considered Bonneville Dam the major menace to its continued prosperity. The dam's location posed a barrier to the spawning grounds of 75 percent of the salmon and steelhead migration. As the U. S. Commissioner of Fisheries recognized, there had "never before been built, in either America or Europe, a structure of such size that obstructed migratory runs of such magnitude."[6]

Contrary to the belief of some of its critics, the Corps of Engineers realized from the inception of planning that the Columbia River dams posed a threat to the fish runs. Colonel Lukesh, in preparing the 308 studies, called the Chief of Engineers' attention to the problem in 1929: "In connection with tentative design of dams . . . it appears that provision should be made for the passage upstream of fish, especially salmon migrating to breeding places." He added, with great foresight, that "such provision may have an important effect upon cost of the dam and possibly upon the water available for power generation during periods of low flow." The final report, submitted in 1931, contained ample evidence of the Corps' desire to deal with the issue. The Portland District Engineer, Major Oscar Kuentz, included fishways in his designs and cost estimates for each of the recommended dams. In their review, a Board of Engineers urged further study of appropriate fish passage facilities, admitting that "for dams of 100 feet or more in height no feasible plans have as yet been fully developed." Kuentz, writing in 1933, agreed with the Board that before actual construction of any dams more study was needed to determine the proper means of preserving the $10 million a year salmon fishing industry.[7]

below: Types of salmon found in Columbia River waters.



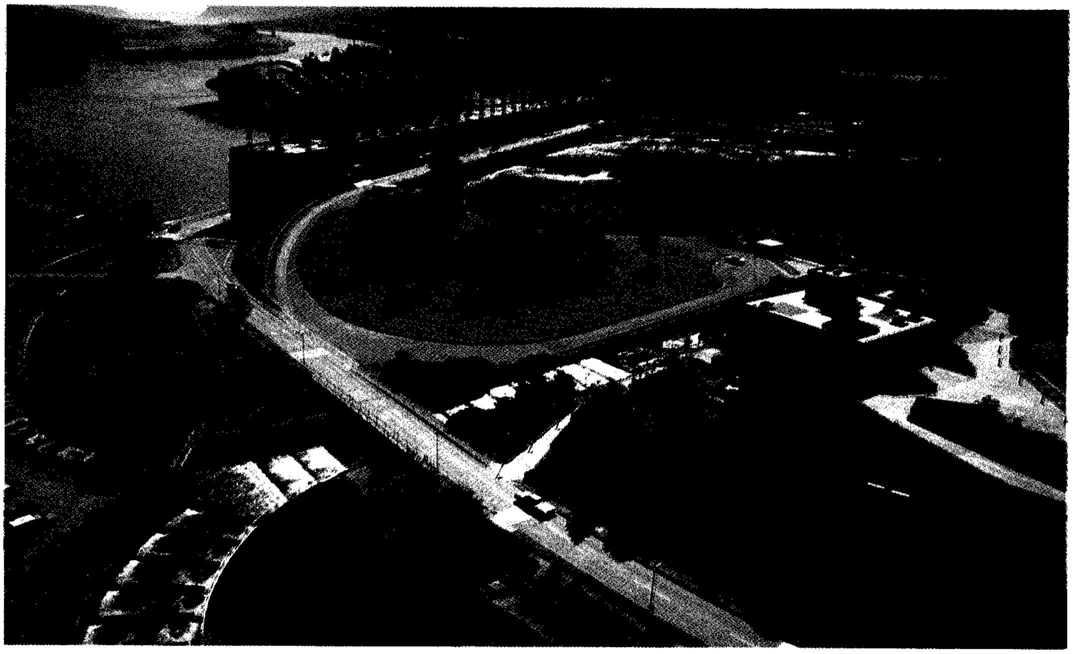
Amidst doubts of the Corps' real concern for the Columbia fishery, the Portland District began work on fish passage facilities at Bonneville Dam. Biologists from the U. S. Bureau of Fisheries worked closely with the engineers. The Corps assembled a team of the best experts available, including aquatic biologist Harlan Holmes and hydraulic engineers Henry Blood and Milo Bell. Working under severe time constraints, the experts assembled existing data, conducted further studies, and submitted their recommendations on 1 September 1934—less than a year after starting the project. Holmes later praised the working atmosphere provided by the Corps, recalling that "from the very beginning our relations with the Corps of Engineers was extremely cordial and cooperative." The Bureau of Fisheries agreed with Holmes, noting that "throughout the study, valuable assistance was rendered by the Corps of Engineers in many details of design of the various structures required." John Veatch, chairman of the Oregon State Fish Commission, assured Senator Charles McNary that "we are very well satisfied with the arrangements for the passage of fish at the Bonneville Dam." Veatch added that

> *Colonel Robins and his assistants at Portland have been at all times most courteous and have worked with us in every way possible. We certainly have no complaint as to the cooperation of the engineers and our work would have been made a great deal more difficult if the engineers had taken a different attitude toward our various requests.*

The Corps modified the initial recommendations as they incorporated them into the actual construction of the dam.[8]

The solution to the problem of providing passage over a dam of unprecedented scale included fish ladders, hydraulic fish lifts, and a novel collection system.[9] The main feature of fish conservation at Bonneville consisted of three fish ladders. They resembled a long stairway comprised of 16-foot long and 40-foot wide pools, each one foot higher than the last. Openings between the pools and regulated jets of water encouraged the fish to swim rather than jump from pool to pool, thereby avoiding injury. The planners located one ladder at each end of the spillway structure and one at the north end of the powerhouse. By passing up these ladders, the fish reached the 70-foot high pool behind the dam.

The system of fish lifts, one at the north end of the spillway dam and another at the south end of the powerhouse, operated on the principle of a navigation lock. Designed to



Fish passage system at Bonneville Dam.

accommodate 30,000 fish per day, the lifts were built in pairs and operated so that one always remained open to receive fish. Once the fish were inside, the operators closed the chamber and raised the water to the reservoir level. A grillage rose beneath the fish to force them out at the top of the reservoir. Initially, Holmes considered the locks superior to the ladders as passage devices, but time proved the opposite.

The fish experts realized that the effectiveness of the fishway system depended in large measure on its ability to attract fish. Fishways at other North American dams had never satisfactorily solved this problem. After careful study, Holmes proposed a collection system that provided "(1) an expanded or multiple entrance supplied with (2) a volume of water much greater than can be supplied through the fishway proper; (3) the addition of this water in such a manner as to produce a nearly constant water velocity from the base of the fishway proper to the several entrances."[10] The ultimate design of the Bonneville fish collecting system faithfully embodied these principles.

Two separate collection systems served the ladders and lifts embedded in powerhouse and spillway structures. Across the face of the powerhouse, the engineers built a flume-like passage with openings for the entrance of fish along its entire length. This channel led to the fishway on the north end and to both the fish lock and navigation lock at the south side of the powerhouse. A series of diffusing chambers supplied auxiliary water at a controlled velocity to attract the fish. The spillway section used a different system. Modified, conventional V-shaped collecting traps across a single gate at each end of this portion of the dam connected with the adjacent fish ladders.

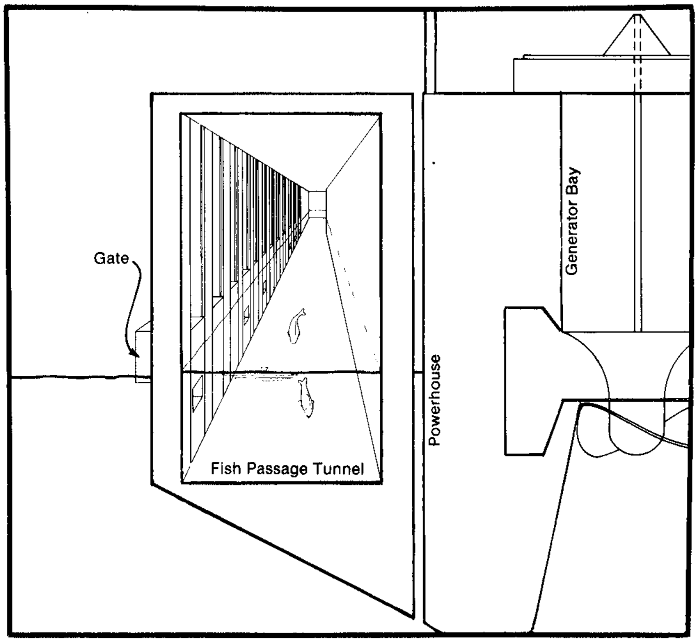


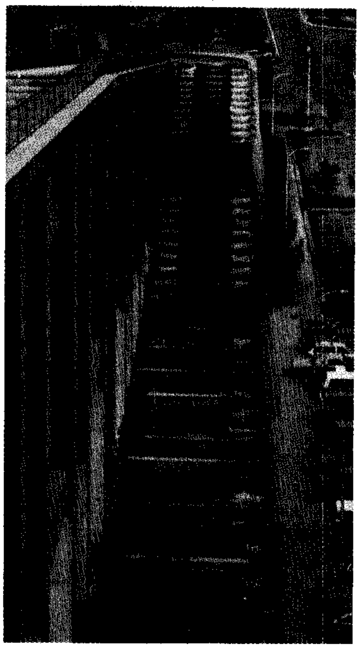
Diagram showing adult fish passage across face of powerhouse.

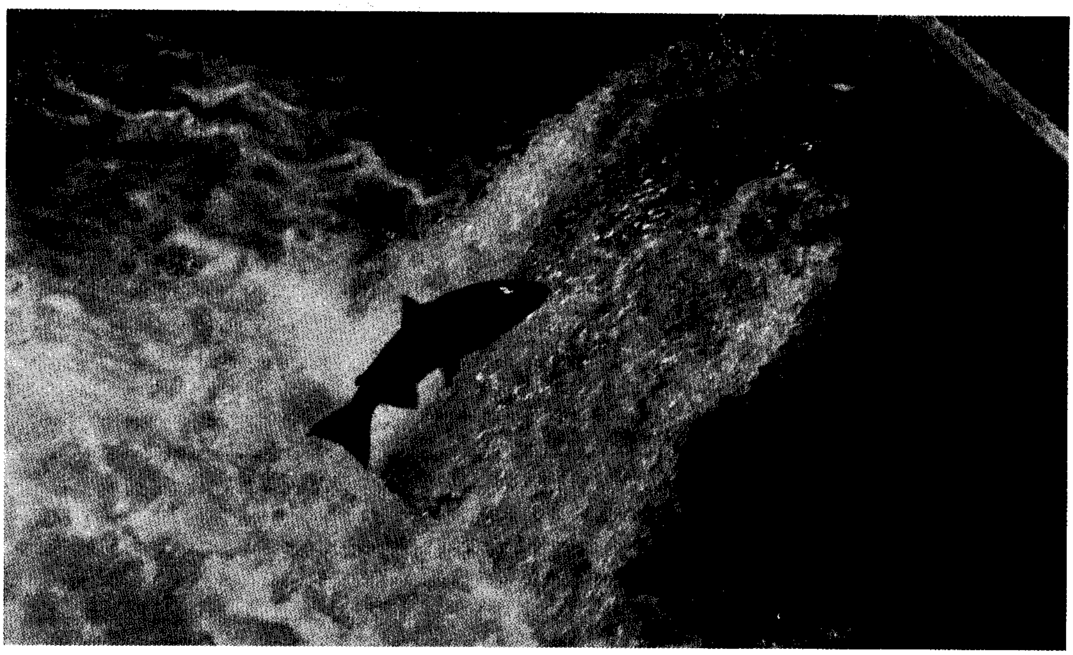
The biologists provided several methods to pass the downstream-migrating fingerlings. At that time, researchers believed that most fingerlings could safely make it through the turbines or the spillway gates when excess water was released. In addition, the engineers provided four special bypasses, three to eight feet wide, at points where the fish were mostly likely to reach the dam. The bypasses, while similar to the ladders in design, were smaller and the drop between pools greater. As it turned out, the fish biologists greatly underestimated the problems of downstream migrants.

Would the $7 million system work? Prior to the closing of the dam in January 1938, the U. S. Bureau of Fisheries admitted that "there is no way of determining in advance whether or not the fish-protective works will be successful or how much, if any, adverse effects the dam will have upon the fish supply." The Bureau optimistically felt that the system would prove "that every possibility of failure or successful operation has been foreseen and provided for." The public, engineers, and biologists anxiously awaited the spring salmon runs which would test the installation. The collection and passage system did not disappoint its designers. The fish readily found their way through the collecting channel and up the ladders to the reservoir behind the dam. During its initial 30 years of operation, the system passed one million fish of various species annually.[11]

below left: Fish ladder's stairstep design lifts fish up to pool behind dam. below right: The instinct to swim upstream urges salmon up fish ladder.

The fish passage success at Bonneville emboldened supporters of the Corps' 308 program for multiple-purpose development to vigorously push for its completion. The popular notion grew that both fish and power were possible: if the salmon could successfully pass one high dam, then why not eight more? It would take several years of study to



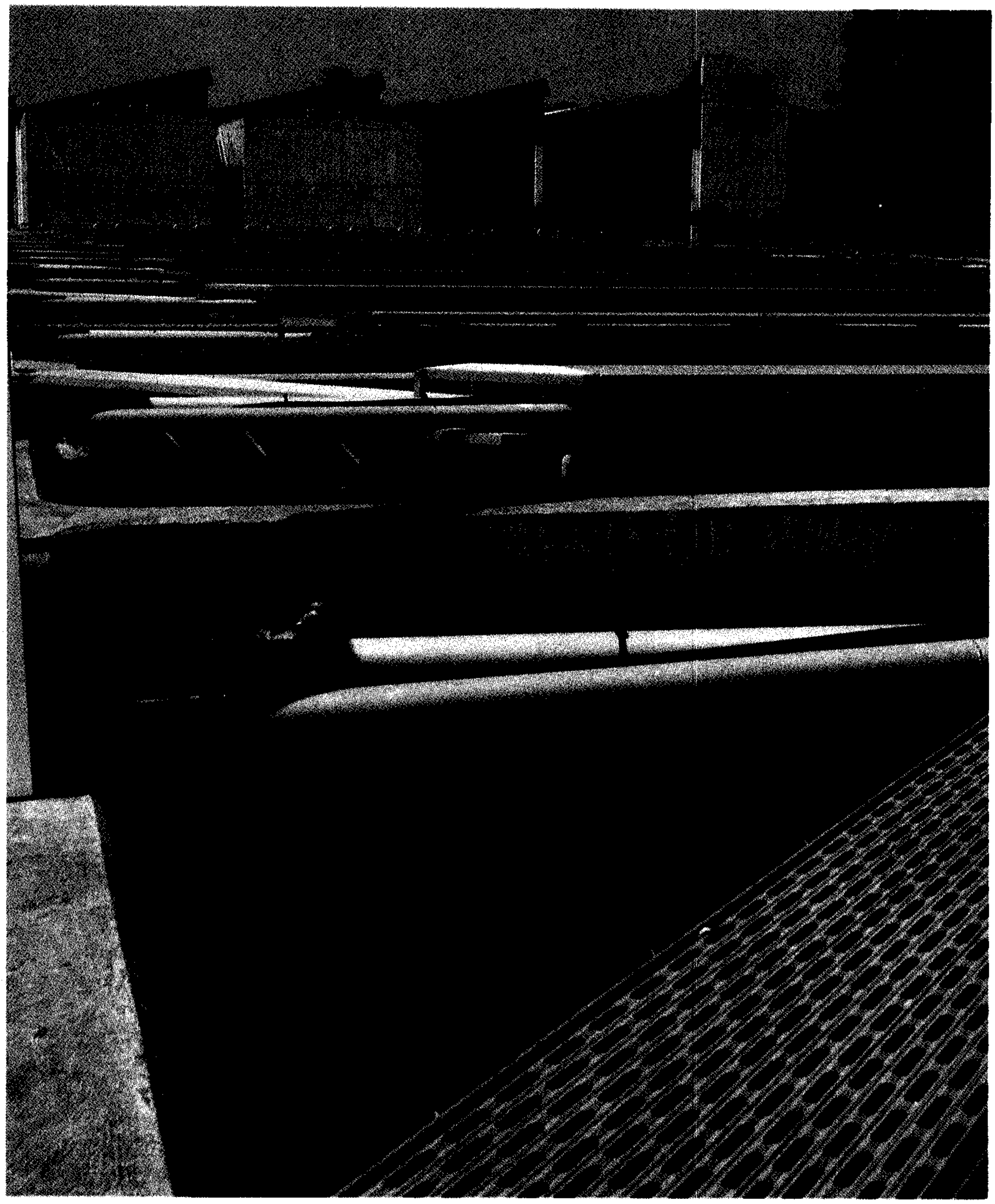


discover that the mortality rate at Bonneville Dam due to various injuries was at least 15 percent of the migrating fish. The cumulative impact of these losses at each proposed dam could all but destroy the fishery resource. In 1947, Paul Needham of the Oregon Fish Commission bluntly expressed the critics' view: "you can't have high dams and salmon too."[12]

Hatchery Program

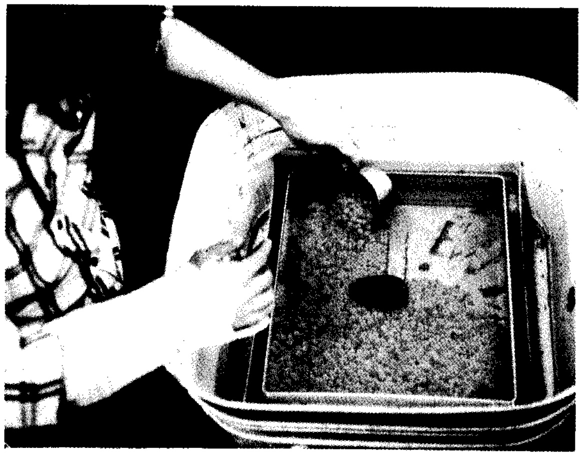
Over the opposition of various fishery interests and numerous fish biologists, the Columbia Basin dams became a reality. Between 1938 and 1975, the Corps of Engineers and public and private utility companies erected eight dams on the Columbia and seven on the Snake. Within the Portland District, The Dalles (1957) and John Day (1967) dams contained fish passage facilities modelled on those at Bonneville and numerous hydraulic model studies. It became evident, however, that fish passage structures alone could not cope with the problems created by extensive hydroelectric development in the lower reaches of the two rivers.[13]

The Corps responded by accelerating a hatching program. Artificial propagation of salmon in Oregon reached back to the efforts of salmon canner Robert D. Hume and fishery expert Livingston Stone. In 1877, Stone established a hatchery on the Clackamas River and Hume, one on the Rogue River. By 1900, federal and state agencies operated a handful of others. Despite many problems, the hatchery effort on the lower Columbia had augmented the fall chinook runs by the 1920s. However, the proliferation of multiple-purpose dams after World War II called for an expansion of the hatchery program—a method still in its infancy. In 1937, the U. S. Comissioner of Fish admitted that "at best it [artificial progagation] is only a supplement for natural spawning."[14]



Bonneville Fish Hatchery constructed by Portland District.

Small salmon in hatchery ponds are cared for until released into river.



right: Eggs are taken from adult salmon, far right: Eggs are mixed and incubated at hatchery.

Small salmon stay in hatchery until large enough to be released into the river for their trip to the ocean.

From 1949 to 1975, the Columbia River Fishery Development Program spent $84 million on building or remodeling 21 hatcheries, constructing 86 fish ladders, and restoration of spawning habitats. These hatcheries account for about 50 percent of the salmon and steelhead produced from the Columbia Basin. By 1974, 44 hatcheries and 13 rearing ponds released almost 152 million smolts. The Corps of Engineers assumed a major role in the hatchery mitigation program. Portland District's portion of the program included financing enlargement of the main Oregon hatchery at Bonneville and constructing numerous propagation facilities in the Willamette River Basin.[15]

The greatest benefit from the hatchery mitigation program has been the increased research that solved many of the problems of salmon culture. Prior to the intensified efforts begun in 1949, biologists had little knowledge of dietary needs, diseases, and rearing requirements of the salmon fry. The development of the Oregon Pellet in 1959 revolutionized the care and feeding of salmon, cutting disease losses. Other improvments combined to increase the survival and return rate of the hatchery fish and to establish new runs on previously barren drainages.[16]

Fish Crisis on Columbia

The cumulative impact of habitat and passage losses, combined with overfishing in the lower Columbia and ocean, created a crises by the early 1970s. The downstream migrants faced an especially acute situation. Each spring young steelhead and salmon began their journey to the sea, carried along by the spring freshet. As a result of the dams along the path, the trip down the Columbia and its tributaries took as long as a month. During this time, heavy mortality occurred from three sources: (1) passage of juveniles through the turbines and over the spillways; (2) migration delays through the reservoirs; (3) and gas bubble disease caused by nitogen supersaturation of river water.[17]

In high water years, dam operators passed excess water not needed for power generation over the dams' spillways, facilitating the fish's passage. However, low water years were hard on the downstream migrants. At these periods, the fish could get past the dams only by going through the turbines. Studies showed that generating units and spillways caused a 15 percent juvenile mortality at each dam. Pressure changes along hydraulic shear planes at the trailing edge of the turbine blades and direct contact with the blades themselves accounted for most of the fatalities. The added time it took for the smolts to travel through the slowflowing reservoirs caused losses from increased predation and failure of the migratory urge.

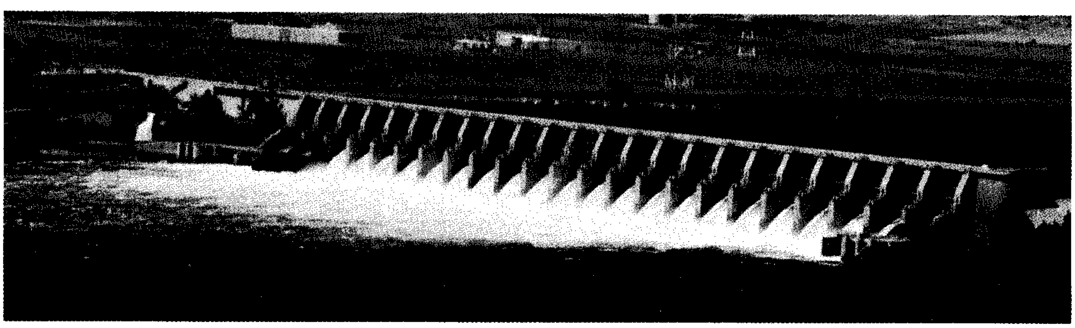
Two factors created the nitrogen supersaturation difficulty. Water released over the spillways plunges deep into the stilling basin, entrapping air which dissolves and produces lethal amounts of nitrogen gas. The effect on the fish is similar to the "bends" in humans. Conversion of the freeflowing river into a series of reservoirs compounds the problem. Water moving slowly from one pool to another prevents the release of the gas and produces deadly accumulations at each successive dam. Saturation levels have reached 140 percent, well above the tolerable threshold for salmon and steelhead.

The impact of these factors has been devastating. Researchers estimated that in 1973 more than 95 percent of all Snake River juvenile salmon were killed before reaching the lower Columbia. From 1972 to 1979, the salmon and steelhead runs on the Columbia and its tributaries generally decreased. In 1975, for the first time in history, authorities prohibited all commercial spring chinook salmon fishing on the Columbia and in the following year closed all sports fishing. During the 1970s, the Corps and state and federal fishery agencies launched a major effort to enhance the downstream migration survival rates.

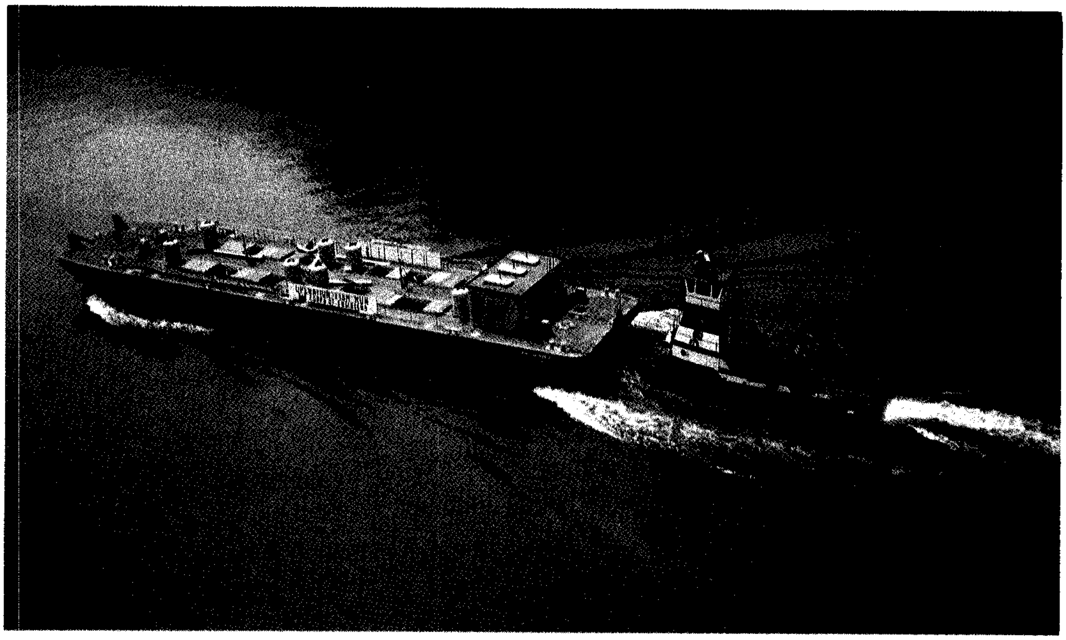
The Corps, as builder and operator of most of the dams, responded to the critical situation with several strategies. The initial use of slotted bulkheads in vacant turbine bays to pass the downstream fish proved unsuccessful; they caused deaths at a rate higher than that caused by the excess nitrogen. Further experimentation led to structural modifications of dam spillways. In 1972, the Corps began testing a plan to reduce nitrogen supersaturation by installation of spillway deflectors at the Columbia dams. The engineers designed these deflectors to direct the spilling water horizontally over the surface of the river and thus decrease the deep water pressure which trapped excess nitrogen. Prototype deflectors installed in three of the bays at Bonneville Dam proved successful, and engineers hoped that the deflectors could reduce nitrogen supersaturation by 50 percent. After analyzing the results of these tests, the Corps installed spillway deflectors at Bonneville and other Columbia and Snake dams. Completion of the second powerhouse at Bonneville will further alleviate the problem there. As a part of its continuing interest in this problem the Corps has a representative on the Interagency Task Force on Nitrogen Control.[18]

In addition to dealing with the formidable challenge of fish disease, the district also moved in other directions to aid the Columbia fisheries. Fish researchers developed methods to force the downstream-moving fish away from the turbines, such as maintaining an adequate river flow and proper spilling. Other modifications, including bypass systems using orifices, deflectors, and submersible traveling screens also proved effective in routing the fish past the turbines.[19]

Since bypass systems are expensive and not feasible at some dams, the Corps started a project called Operation Fish Run.[20] Begun in 1971, this project has entailed the transportation of juvenile salmon around the Snake and lower Columbia dams. In cooperation with the Walla Walla District, Portland Corps personnel collected large numbers of salmonids and transported them either by barge or truck around the dams and released them below Bonneville Dam. Barges, though slower than trucks, caused less stress and aided in homing because the fish were kept in tanks below water level. River water circulated through the tanks at all times, thereby allowing the juveniles to "imprint" on the river water during the trip downriver. This imprinting process enabled the returning adults



Releasing large quantities of water helps small salmon cross the spillway avoiding the turbines.



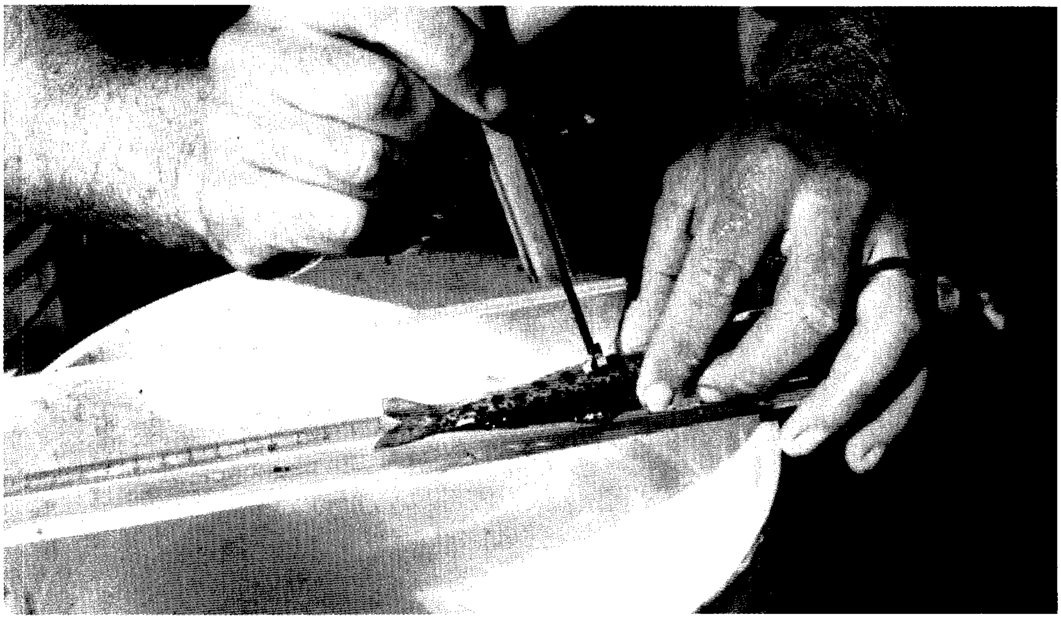
Operation Fish Run barged large numbers of juvenile salmon down the Columbia River to release areas.

to find their native stream accurately. Tests showed that survival rates of transportated over untransported juveniles have ranged from 4 to 1 in most years to 15 to 1 during low flow years.

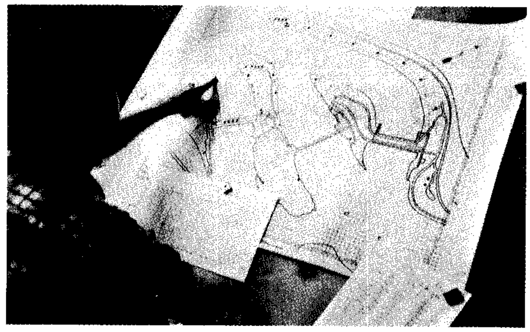
During the abnormally low-water spring of 1977, the problem of potential fish loss was acute. To save the fish, the Corps agreed to a plan that required both transporting massive numbers of fish and increasing water flows over the spillways of Columbia River dams. In May 1977, one part of the plan, Operation Fish Flow, began. This complex plan, coordinated by the Corps, the Bonneville Power Administration, the Bureau of Reclamation, and federal and state fish and wildlife agencies provided an artificial spring freshet so that the juvenile salmon would be washed safely over the spillways of nine dams along the Columbia River. The operation resulted in the release of about two million acre-feet of water—even at the cost of lost electric power—and enabled 28 percent of the downstream migrating fish to escape death in the turbines.

The other part of the plan, called Operation Fish Run II, consisted of collecting and then transporting by truck, barge, and plane the downstream migration of juvenile fish which would be passing through the dams on the Snake and lower Columbia Rivers. Almost 2.2 million fish were hauled in the operation, nearly two-thirds as many as were moved in the preceding six-year period. Including the hatchery fish also moved by barges, the total hauled amounted to 5,417,000. In the face of certain disaster, the Corps, cooperating with other public agencies ensured the survival of the annual fish run to the sea.

Since the success of the 1977 rescue operation, the Corps has invested heavily in the collection and transportation of juvenile salmon. In 1977, the program cost almost $800,000,



Some small salmon are branded for identification upon return.



right: Radio transmitter is inserted into adult salmon as it moves upstream. far right: Radio transmitter enables fisheries biologists to track adult fish as they maneuver around Columbia River dams.

while in 1980 the Corps spent $1.3 million transporting 10.4 million smolts. Research continues on refining the bypass and transportation systems, with the goal of hauling 15 to 20 million juveniles annually.

The most recent effort to enhance the survival of noncollected migrating juveniles involves the use of sophisticated electronic tools and sonar devices. In 1979, the Portland District, at John Day Dam, began testing sonar monitoring to direct spill patterns which stimulate fingerlings to pass through spillways and away from powerhouses. The goal is to increase safe fish passage while reducing losses in hydroelectric production and revenues.[21]

Fish Conservation on the Willamette River

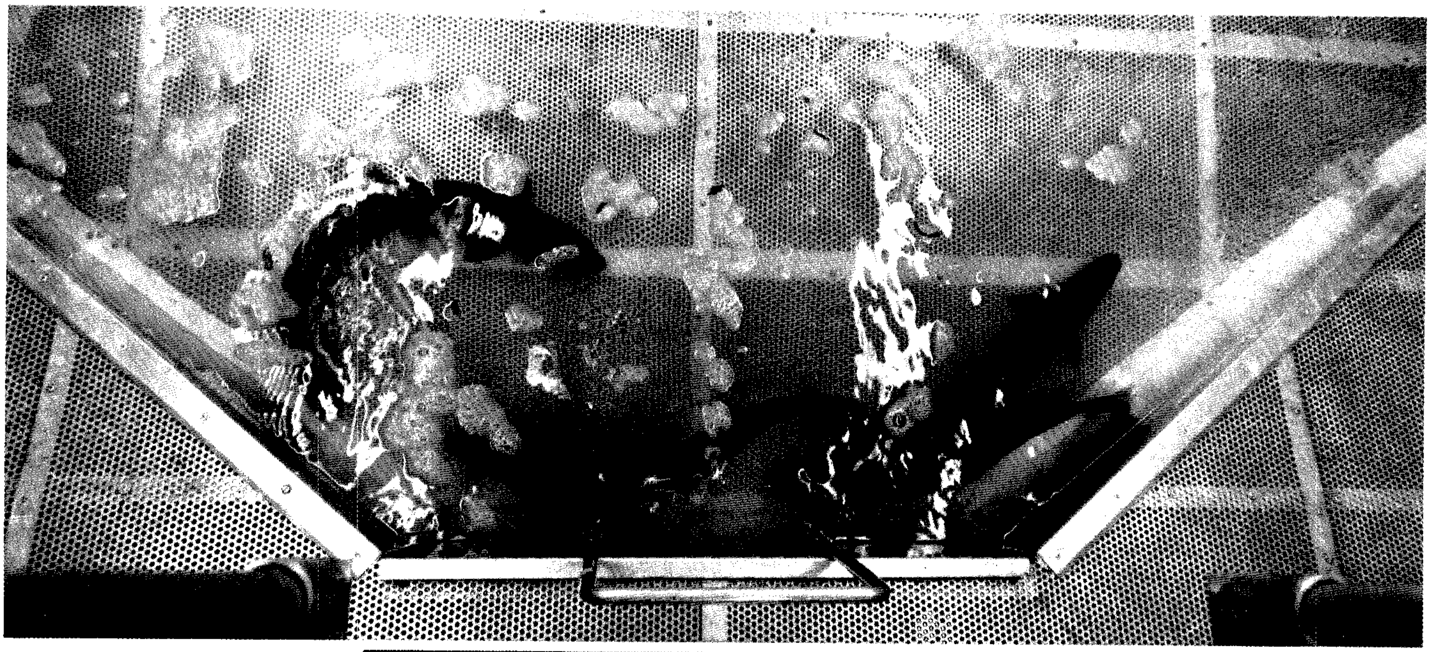
Planning for the Willamette Valley multiple-purpose dams also included provisions for protecting the existing fish resources. The species affected included salmon, steelhead, and nonmigratory trout. By the late 1930s, a program of hatcheries on tributaries of the Willamette sustained both the salmon and resident trout. The proposed dams on the North and South Santiam, McKenzie, and Middle Fork Rivers, from 149 to 259 feet high, would block the migratory runs. Moreover, the reservoirs would submerge existing hatcheries on the Middle Fork and on the North and South Santiam and require the relocation of existing egg-taking stations.[22]

Once again, the Portland District called in aquatic biologist Harlan Holmes for consultation. The height of the storage dams and the large seasonal variations in pool levels indicated that fish ladders or lifts were not feasible. The Corps accordingly recommended "extensive and enlarged modern hatcheries . . . to replace or supplement the existing hatcheries . . . as a substitute for the natural spawning grounds made inaccessible by the proposed improvements." The plan required an estimated expenditure of $1 million. In addition, the Corps promised to regulate stream flows in such a way as to enhance fish life on the main stream.[23]

The program did not satisfy all fishery experts. The U. S. Commissioner of Fisheries questioned the Corps' assertion that the storage dams "will not affect resident fish life in the tributaries above the reservoirs." The Commissioner felt that since the lakes behind the dams were for flood control, their fluctuations for this purpose "would render them useless or even dangerous to resident fish populations." The Oregon State Fish Commission publicly opposed construction of the dams on the grounds that fish life would be affected adversely.[24]

The Portland District was fortunate that the first three projects it built before World War II—Fern Ridge, Cottage Grove, and Dorena—had no significant runs of anadromous fish passing upstream. Since no fish facilities were needed on these structures, the district

Leaburg Fish Hatchery in Willamette Valley



above: Adult fish are collected at Willamette Valley dams.
right: Collecting young fish for release.

concentrated on finding solutions to the fish problems associated with the Willamette River Basin projects proposed for later development. Major Cecil Moore, initiated such study in April 1939, even before Congress had appropriated funds for construction on the first dams. This started another phase in the cooperation between the Corps and the Bureau of Fisheries.[25]

The fish passage facilities provided at Cougar Dam failed to perpetuate the spring chinook salmon run on the South Fork of the McKenzie River. To mitigate these losses, the Portland District, at the urging of the U. S. Fish and Wildlife Service, expanded the Leaburg hatchery and financed half of the cost of the McKenzie River Fish hatchery. The District maintained fish runs on the North Santiam and Middle Fork Rivers, blocked by Detroit and Lookout Point Dams, through the Oakridge and Marion Forks hatcheries. Although the Corps of Engineers built these propagation facilities, the state of Oregon operates them.[26]

The Portland District constructed unusual fish passage facilities at the Green Peter and Fall Creek Dams. At Green Peter on the Middle Santiam River, engineers installed a ladder and lift system. Upstream migrants are attracted to the short fish ladder leading into a hopper which lifts the fish over the dam and to the reservoir on the upstream side. The Corps provides a trucking service for fish arriving at Green Peter Dam late in the spawning season. If the fish appear too ripe to swim the length of the reservoir, a special water-filled truck assists them. Downstream migrants at Green Peter are collected by a hornshaped device which can be raised or lowered to suit the fluctuating reservoir. Foster Dam on the South Samtiam River, reregulates the discharge of Green Peter Dam and has a similar, but smaller, lift facility as Green Peter. Downstream fish travel through the turbines; the special design of the turbines allows this unorthodox passing method. The cost of the fish works at Green Peter and Foster total $3,400,000. Below the Green Peter-Foster complex is the South Santiam Hatchery, completed in 1968 at a cost of $400,000.[27]

Fall Creek Dam, located at the confluence of Fall and Winberry Creeks, tributaries of the Middle Fork River, also includes unusual facilities to pass migrant adults upstream and fingerlings downstream. A fish trap collects upstream migrants at the foot of the dam. From here, fish are transported and released in Fall Creek and Winberry Creek to spawn naturally upstream from the reservoir. Fingerlings working their way downstream pass Fall Creek Dam through a collection system and fingerling bypass conduits. Intakes for the collection

above: Collecting fish.

system are set at three different elevations so that the fingerlings have easy access at all reservoir levels. Artificially created water flows attract the fish to the collection system. Completed in 1967, the passage facilities at Fall Creek Dam cost about $1.5 million.[28]

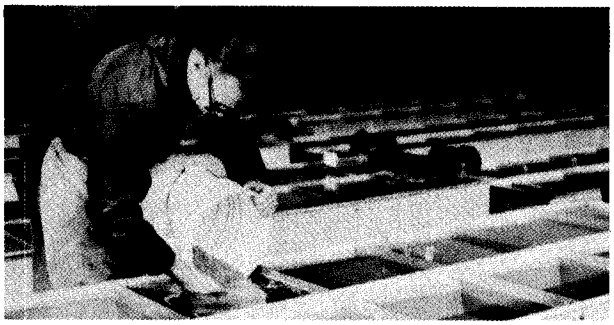
Fishery enhancement served as one of the primary purposes of the Corps' improvements in the Rogue River Basin in southwestern Oregon. To accomplish this goal, the Portland District designed three multiple-purpose dams to provide not only mitigation but also water storage specifically for improving stream flow and ameliorating water temperatures on the Rogue. After extensive investigation, the Corps sited the reservoirs upstream from the principal salmon-spawning areas. To provide restitution for rearing areas unavoidably lost from construction of the three dams, the district built the Cole M. Rivers fish hatchery, the largest in Oregon.

Corps engineers designed a unique intake tower for Lost Creek Dam which permitted selection of the depth from which water would be drawn for temperature regulation of downstream discharges. In order to study the long term effects of Rogue River dams on the salmon and steelhead life cycle, the Portland District entered into a cooperative research program with the Oregon Department of Fish and Wildlife in 1974. The nine-year study included analysis of life-pattern, physiology, hatchery propagation, and water temperature changes and turbidity caused by dam operations. When closure of Lost Creek reservoir in 1977 threatened to leave salmon eggs and fry without water, the Corps devised an ingenious sprinkler system to keep the streambed wet and save the fish and eggs.[29]

The Portland District has been involved actively in fishery matters since the 1880s. The district's biggest challenge in this area came with its 20th century mission to build multiple-purpose dams on the Columbia and its tributaries. Despite the charges of its numerous critics, the Corps recognized early the dangers posed to the valuable runs of anadromous fish by these enormous dams and attempted to deal with the problems in a direct manner. Seeking the best fishery advice possible, the Corps designed its projects with fish passage and artificial propagation facilities.

By the 1970s, its research program had developed five conservation technologies to deal with fish losses: (1) installation of spillway flow deflectors to lower nitrogen supersaturation levels, (2) screening of turbine intakes to protect downstream fingerlings (3) collection and transportation of downstream migrants around main-stem dams, (4) improvement of fishway designs, (5) and flow manipulations at main-stem dams. To 1975, the Corps spent $252.9 million on its Columbia River and tributaries fishery program.[30]

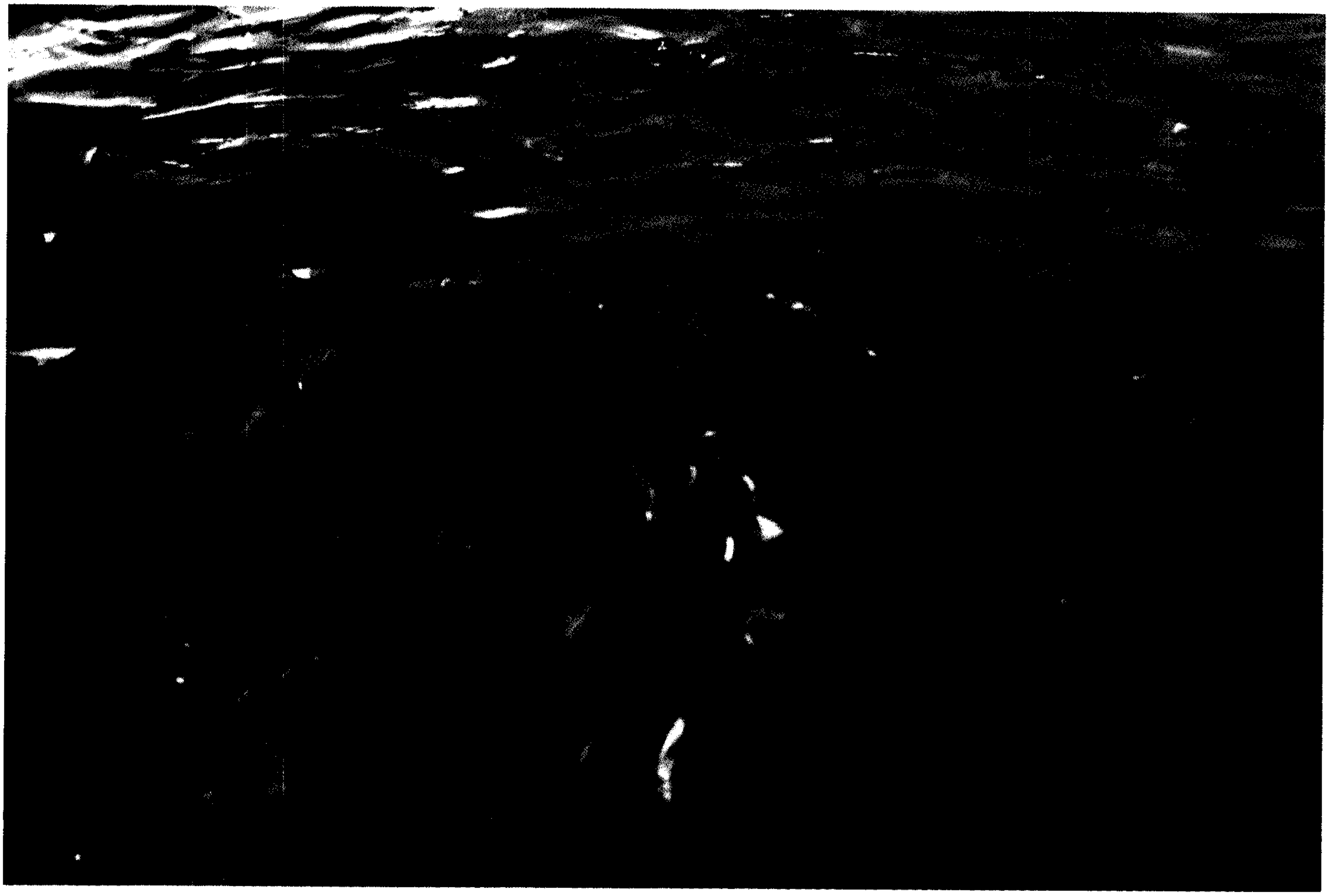
Sprinkling fish spawning area of Rogue River below Lost Creek Dam.



Hatchery work at the Cole M. Rivers facility, largest fish hatchery in the state of Oregon.

The expansive Cole M. Rivers Hatchery on the Rogue River.

How successful was this enormous investment? The continuation of the cumulative annual 15 percent loss at the main-stem Columbia and Snake River dams, despite heroic corrective measures has left the anadromous species in serious trouble. Uncompensated losses from overfishing and habitat degradation have compounded the problem. If there has been any short-coming in the Corps compensation plan, it has been an over-reliance on scientific and engineering solutions, combined with a lack of awareness of the important social and economic impact of the dams on the lifestyles and livelihoods of the various groups dependent upon the Columbia Basin's fish resources. As the Pacific Northwest Regional Commission has noted, ignorance of the social and economic impact has been a deterrent to sound decision making in "protecting and/or receiving compensation for salmon and steelhead threatened by competing demands on land and water resources."[31]



Migrating salmon exit from The Dalles Project fish ladder into upstream reservoir.

The struggle to save and enhance the fish runs on the lower Columbia and Willamette is one of the few bright spots. Here wild stocks are supplemented with large numbers of hatchery fish. The fall chinook and steelhead are the chief beneficiaries of the mitigation program in the Willamette Basin. Hatchery compensation, however, is only part of the solution. Effective compensation efforts require habitat restoration and preventative measures to maintain the quality of remaining natural spawning areas.[32]

The pressure on the fishery resource remains enormous. Population growth and resource development in the Pacific Northwest will maintain the competition for limited water resources. Water for power, irrigation, industrial, and domestic use will, as fish biologist Kenneth Thompson points out, "tax the ability of salmon and steelhead to survive unless natural resource managers can learn how to absorb the demand without sacrificing the quality of the Northwest's aquatic ecosystems."[33] The Portland District will continue playing a large role in fishery management of the Columbia and its tributaries.